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ABSTRACT

This booklet contains the third in a series of three interdisciplinary units which focus specifically on the Pacific Ocean and its surrounding countries. The unit, intended primarily for upper secondary students, consists of readings and interdisciplinary activities (science, art, social studies, English, and home economics) presented in four parts. Part 1 looks at the issue of using the sea wisely in broad terms and raises the question of the world's food problem and present and potential ocean resources. Part 2 gives a basic introduction to some concepts of international law as they relate to the law of the sea. A case study on the regulation of whales is included. Part 3 examines the main sources of ocean pollution, focusing in particular on oil spills and chemical effluent from industry. The importance of and damage to shoreline and estuarine systems is addressed, as is the effectiveness of the Kuala Juru Co-operative in Malaysia, where local inhabitants responded to pollution by creating a new aquaculture fishery and administering it through a cooperative. Part 4, which focuses on fishery management, includes a case study on the state of the Southern Bluefin and discussions of ecosystem management, aquaculture, and finding alternatives for fish and fish products. (JN)

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One of the aims of the Pacific Circle Consortium is the development of educational materials with an international perspective, particularly materials that take into account the half of the earth's surface covered by the Pacific Ocean.

The Consortium works on the assumption that educational materials about other people and other cultures will be most accurate and genuine when developed jointly, by people from the country using the materials and people from the country being studied.

Harvesting the Ocean includes material from many Pacific countries and cultures. It has been developed and published as the result of co-operation between many people in a number of different countries. For their assistance and co-operation, and especially to Helen Connell, and to the Northwest Regional Educational Laboratory, Portland, Oregon, USA, we express our thanks.

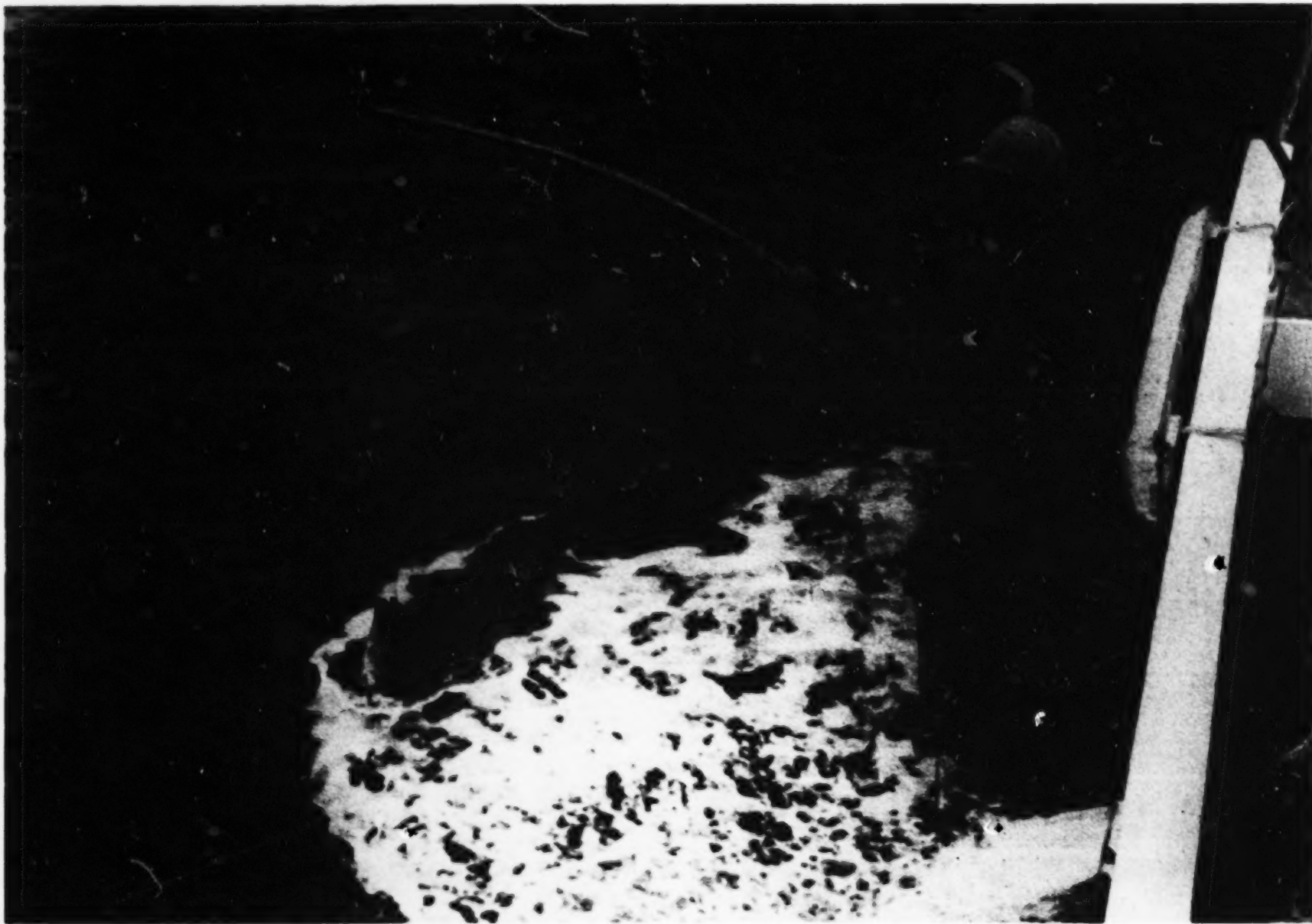
3. Using the Sea Wisely

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1.0 Using the Sea Wisely

The resources of the ocean are vast. Its food resources are already being harvested on a large scale. Its mineral resources have been barely touched. Only recently have we developed the technology needed to 'mine' the ocean floor for oil and valuable metals.

How can we make the best use of these resources without destroying the natural environment? Who has the right to fish and mine the seas? Which of us will benefit from the wealth of the oceans? What happens when nations disagree over these questions?

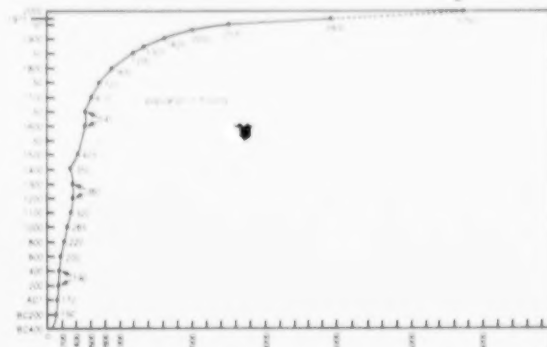
The answers to these questions are of vital concern to all of us and will be for many years to come. This book examines the most important issues involved in the question — how can we manage the sea wisely?



1.1 The Sea — the Answer to the Earth's Food Problem?

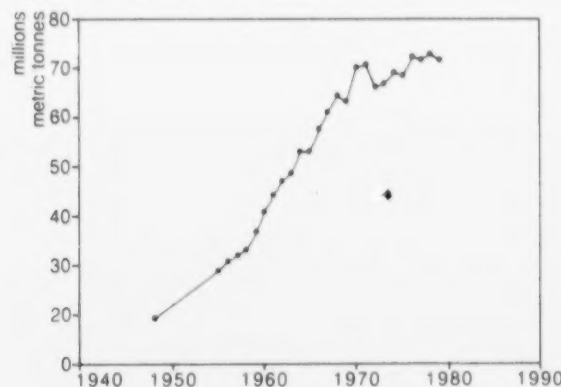
One of the biggest problems facing the nations of the world is a rapidly increasing population. Figure 1 gives you an idea of just how big the recent increase has been.

Figure 1 World Population



Can the sea, if properly used, provide enough high quality protein to feed these huge numbers? Figure 2 shows the increase in the world's fish catch since 1948.

Figure 2 Total World Fish Catch: FAO data.



For a while there was optimism that the sea could, if not solve our nutritional problems, then at least help us to overcome them. We greatly increased our world fish catches. We developed sophisticated plant and ships which could catch, clean, process, and quickly transport vast amounts of fish across long distances. We learned to locate fish by sound location and aerial spotting techniques. We developed new fish products like fish sticks, fish sausage and high protein concentrates (low fat, bland, practically odourless powder produced from whole fish which can be used in the production of biscuits and other food combinations).

The Fisheries Division of FAO* regularly reviews the state of the world's fish resources as part of the essential background information for discussions of world fishery problems and policies. The total world catch in 1977, estimated at about 73.5 million tonnes, was about a million tonnes below the record figure of 1976, mainly due to a fall in the catch of Peruvian anchovies. This is consistent with the trend since 1970, of a global production fluctuating about a very slow upward increase (1-2% per year). However there are possibilities for further increases from different groups of species. From the more familiar types of fish we can estimate that present catches, all factors being favourable, might be nearly doubled. Of this extra 50 million tonnes, about 20 million could come from the rebuilding and better management of stocks presently depleted or heavily fished (especially anchovies and herring), and about 30 million from increased fishing of those stocks at present lightly or moderately exploited.

Today we produce enough food to feed the world, but the distribution of food is quite unequal. We in the rich countries have more food than we need, the poor have less. The problem is aggravated in times of drought or shortage — the wealthiest nations tend to sell only to each other, as they can pay the highest price.

*Food and Agriculture Organisation, a division of the United Nations

Prospects are bleak. In 35 years the world population will double, mostly in the poorer countries where the shortage of food is most acute. Experts agree that even with improved technology, and using all arable land, the world food production cannot increase to more than double in less than 35 years. The problems we have today will remain and grow worse.

How much help can we expect from the ocean? The catch of familiar fish can be increased to just over 100 million metric tonnes without counting the contribution of aquaculture (see Section 4.3). The oceans also contain large quantities of fish that are presently either not harvested or only very lightly fished because either:

- there is no demand because of their unfamiliarity;
- they require special fishing or processing techniques;
- they occur in remote areas.

The squid of the open ocean, the krill of the Antarctic and various small fishes living near the surface of the open ocean are examples. FAO suggest that this group may ultimately yield another 150 million metric tonnes — principally from the squid and krill (about 50 million tonnes each).

To achieve this improved production we must first regulate current fishing to see that each fish resource is safely harvested. Those fisheries that have been over-fished in the past can be rebuilt if the right management measures are now applied. The cessation of fishing in the North Sea and North Atlantic during both World Wars clearly demonstrated that fish stocks will quickly recover if fishing pressure is removed.

Technological advances will allow the catching and processing of oceanic squid and krill in the future but some of the problems we face are **political**. They relate to questions of right and fairness. Nations must agree among themselves on the best and safest ways of using new technology in the development of food resources. They must also agree on the fairest way of distributing them.

It's the same with the ocean's mineral wealth. We all know that there are huge quantities of petroleum oil and natural gas below the ocean-floor, and offshore oil rigs are a common sight in certain parts of

the sea. Did you also know that the sea also contains a great quantity of valuable minerals — lead, copper, gold, platinum, magnesium, sulphur, cobalt, nickel, aluminium, iron and manganese? The Pacific Ocean alone has 1.5 trillion tonnes of manganese in lumps called **nodules**, lying on the ocean floor. When recovered this would sell for more than \$100 a tonne.

Only now have we developed the technology to recover these resources from the sea. The important questions that remain are **environmental**, **political** and **economic**.

- Environmental — how can these riches be mined without destroying the natural environment of the ocean?
- Political — who is entitled to this vast wealth?
- Economic — the advanced technology is expensive to build and sometimes to operate — this makes the product expensive to sell.

The issues relating to both food and mineral resources are fundamentally the same. How can the natural riches of the sea be used most wisely?

What are the effects of mining and harvesting on the **natural** environment?

What are the effects on the **social** and **economic** environment — the wealth of nations and the people who live in them?

These are the questions that we'll be exploring in Book 3. Unlike the issues highlighted in Book 2 — which were largely issues of knowledge and know-how — Book 3 is primarily concerned with values. Different cultures often have different values. How then do we arrive at some commonly agreed upon set of guidelines? Is it possible to agree on a 'common good'? To draw up a body of rules and stick to them?

In the next section we will be looking at some very important attempts to do just that.



■ squid

2.0 The Law of the Sea

A new attempt at world order — perhaps as significant as the creation of the United Nations — is underway. It's an attempt to bring a new order to the world's oceans: to resolve such issues as freedom of navigation, environmental protection and access to nationally claimed waters. More and more nations are saying: 'No fishing, no mining, no scientific research without our consent for 200 miles from our shores.'

Mark J. Valencia 'Danger Signs in the Pacific: No Trespassing for 200 Miles' *East-West Perspectives* Summer, 1979

As Mark J. Valencia writes: The stakes are high. The oceans contain some of the world's last untapped resources. The development of new technology has enabled us to reach the ocean floor and discover vast quantities of important minerals lying there, as well as much needed oil and gas. Soon the technology to mine these minerals will be perfected and nations are already disagreeing as to who should have the right to mine them, and who should profit.

As well, the ocean is an important food source. World population growth has increased the demand for food fish. It has become a matter of great importance as to which nations have the right to fish in which areas.

At no time in our history has there been a greater need for agreement on a set of rules to govern the use of ocean waters and the drawing up of a new Law of the Sea.



2.1 The Freedom of the Seas

For centuries the world's oceans were regarded as belonging to no-one. As a result they were taken over, exploited and divided up by the powerful maritime nations with large navies which set about exploring unknown seas and colonising new worlds.

In the 16th century, the Pope divided the 'ownership' of the world's oceans between Spain and Portugal which at that time had done the most ocean exploration.

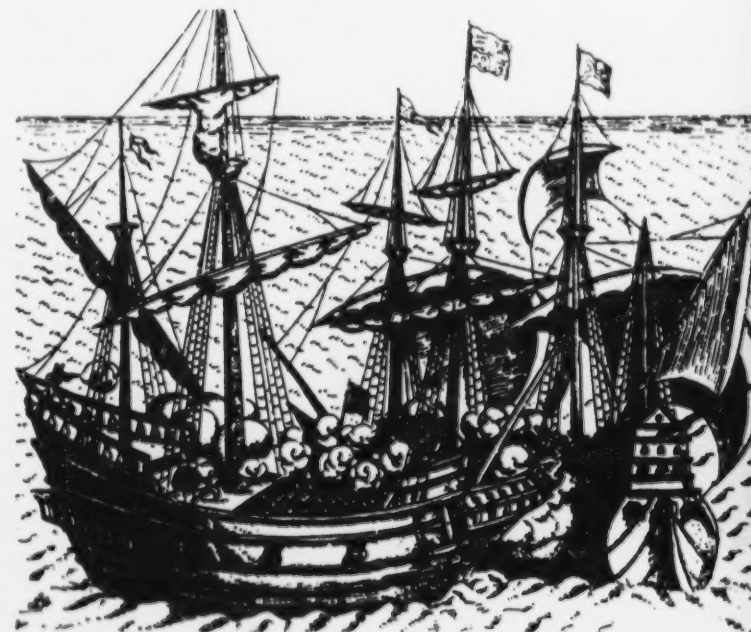
But this wasn't accepted by England, another great maritime nation. When Philip II of Spain warned Elizabeth I of England to order Francis Drake not to enter the 'Spanish' waters in the Pacific she replied:

'The use of the sea and air is common to all; neither can any title to the ocean belong to any people or private man, forasmuch as neither nature nor regard for the public use permitteth any possession thereof.'

By the 18th century international law had developed a general principle that the great oceans of the world, and the many seas, gulfs, bays, bights and straits connected to them, should be the property of no one nation but a sort of 'common' available to everyone. Thus anyone could sail on them, or catch fish or whales in them. They were the 'High Seas'.

International law came to recognise two exceptions. The first exception, and this is still established law, was 'internal waters' connected to the seas; that is, waters substantially surrounded by the land territory of the nation. These were and are treated as part of the nation in question. Examples in Australia are Port Philip Bay in Victoria and Port Jackson in New South Wales. Examples in the U.S.A. are many of the harbours such as those of New York, San Francisco and Chesapeake Bay.

The second exception was that each nation with a sea-coast was allowed a 'Territorial Sea' along the coast, with a width varying from three to six miles. (A nautical mile is 1.152 land miles, 1.853 km.) This was the area which could be reached by 18th century



land-based cannon; the range of ships' cannon was less than three miles. The coastal states had almost the same rights in their Territorial Seas as on land, but had to allow shipping of other countries to pass and repass for purposes of 'innocent navigation'. Whether this extended to warships and government-owned ships was often disputed, and shipping rights were often curtailed in wartime.

The freedom of the seas did not mean that there was no law on the High Seas. Piracy was recognised as a crime by international law. Every coastal state was entitled to make its laws applicable to ships connected with it by various tests — ownership, registration, 'home port'. Some coastal states made agreements to control fishing to preserve stocks.

2.2 The United Nations and the Law of the Sea Conference

In 1945 President Truman of the U.S.A. issued a Proclamation on behalf of his country announcing that henceforth it would regard the ocean and ocean bed along its coasts to the limit of the 'continental shelf' as lying within its exclusive control for the purposes of petroleum drilling, fisheries management and other activities. In the previous twenty years scientific discoveries had directed attention to the importance of the shelf, the edge of relatively shallow waters around the continents after which there is a sudden plunge into greater depths. This shelf could obviously be regarded as an extension

beneath the sea of coastal lands, and it was known to contain valuable deposits of petroleum and to sustain large fish stocks.

Shortly after President Truman's announcement several other countries laid claims to extend the width of the Territorial Sea. It became obvious that it was time for the world's maritime nations to sit down together and rethink the whole question of freedom and regulation of the seas.

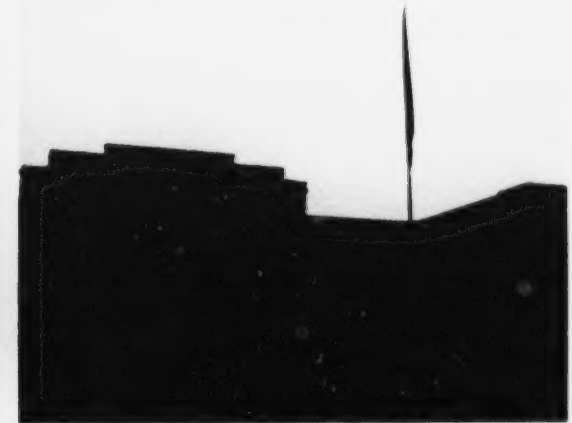
The United Nations then organised a conference of nations at Geneva, the first U.N. (1953) Conference on the Law of the Sea. This was followed by a

second Conference in 1960, and then a third — often referred to as UNCLOS III — which began in 1974 and was still in progress in 1982.

Among the results so far has been an agreement to establish a **Territorial Sea of 12 nautical miles** for each coastal nation and what is called an **Exclusive Economic Zone** of up to 200 miles from the coast or the edge of the continental shelf, whichever is further. The coastal state has exclusive control of the seabed resources of the shelf and great powers of regulation in the sea over it. As a result, an enormous area of what used to be High Seas has been transferred to the control of individual nations. The area of High Seas beyond coastal control is reduced to less than 40% of the total area of the oceans and seas.

UNCLOS III has codified the rules of customary international law in relation to the High Seas. The freedom of the High Seas, the remaining 40%, is to include the following:

- freedom of navigation
- freedom of fishing
- freedom to lay submarine cables and pipelines
- freedom to fly over the high seas



U. N. Building, Geneva

2.3 The High Seas and the Common Heritage of Mankind

In 1970 the United Nations Assembly unanimously declared that the High Seas, (now meaning the less than 40% as described before) make up 'the common heritage of mankind' and must remain so. Who then will have the right to exploit the resources of the deep-sea bed, the nodules made up of manganese, nickel, cobalt, copper and other metals lying loose on the ocean bed at great depths?

UNCLOS III recommends proposals which, if adopted, will ensure that the resources of the deep ocean bed will be used in part for the benefit of the so-called Developing Countries — the poorer nations of the

world. At the UNCLOS III talks the poorer countries, which are in a majority, wish to place the deep-sea bed resources under the control of an international authority which will regulate the mining, recover and sell part of the product, and share the profits between the developing nations. Other countries, particularly the U.S.A., want to leave this development to private companies. The UNCLOS III draft of 1981 provided for a mixture of private business and international control, but it is not certain that the U.S.A. (and Japan) will agree. The matter is still unresolved.



CSIRO Research ship with Japanese vessel



2.4 Environmental Protection and Conservation

Until about 50 years ago it was thought that the oceans* and their resources were so enormous that there was no question of protecting or conserving them, but since then we have learned better.

Economic reasons were the earliest, and are still the most powerful factors inducing fishermen to accept limitations on their right to exploit the oceans and the sea-bed. For example, it became clear that over-fishing might destroy the herrings of the North Atlantic and North Sea and the salmon of the North Pacific.

Similarly with the effects of pollution. The UNCLOS Conventions of 1972 and 1973

- forbid discharge of especially poisonous substances such as mercury
- require licences to discharge moderately poisonous substances
- make ship owners responsible for accidental spills
- bring the operations of under-sea petroleum drillers under control.

Control of nuclear waste is covered by other Conventions. All these Conventions are still in draft form, that is, they have not yet been agreed to in all details by enough nations to yet be considered as law.

If UNCLOS III reaches a successful conclusion, even without a deep-sea mining part, it will for the first time require states to protect the natural environment of the oceans and to preserve its living species.

In the next section of this book we look in detail at the need for protecting the ocean and the ways in which we can achieve pollution control.

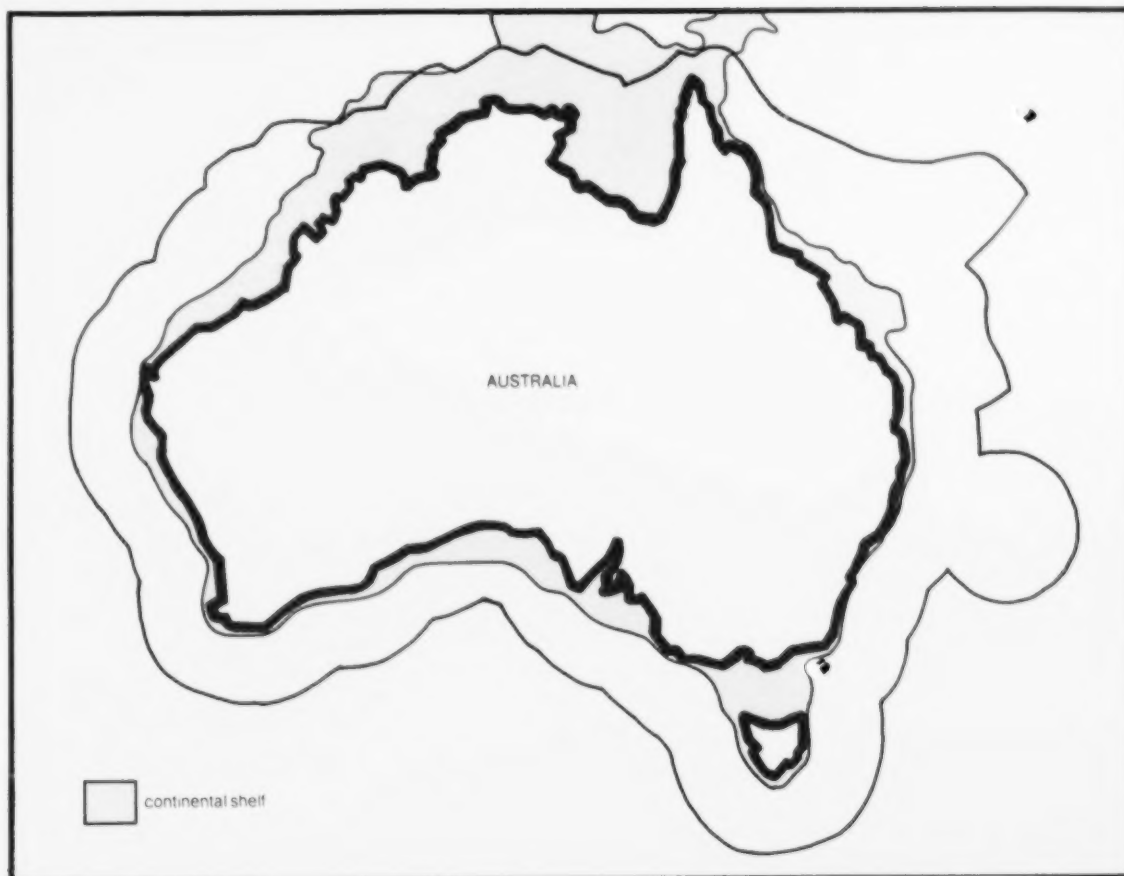


Figure 3. The Australian coastline showing the boundary of the 200-nautical-mile Australian Fishing Zone and the contour which marks approximately the edge of the continental shelf.

2.5 Case Study: The Regulation of Whaling

Whales travel huge distances through the oceans each year, spending summer at the Poles and winter in the Tropics. During their journeys, they pass near the shores of many countries. Southern Hemisphere stocks also spend a lot of time in the waters of Antarctica, which belongs to no country although several nations claim a part of it.

Whales have been hunted by humans for hundreds of years. This century, it became clear that whales had been over-hunted and their numbers were

Norway, Peru, Spain and the USSR. Some subsistence whaling is still carried out by the native inhabitants of Denmark (Greenland), USSR and USA.

The other members which do not hunt whales are:

Antigua-Barbuda, Argentina, Australia, Belize, People's Republic of China, Costa Rica, Oman, Philippines, St Lucia, St Vincent and the Grenadines, Denmark, Dominica, Egypt, France, Federal Republic of Germany, India, Senegal, Seychelles, South Africa, Sweden, Jamaica, Kenya, Mexico,

sion include:

- classification of whale stocks (endangered, lightly exploited, etc.)
- protection of certain species
- setting limits to the number of whales that may be taken, by species, area and sex
- setting size limits for whales that may be taken
- setting the length of the whaling season
- limiting the areas where whaling factory-ships may be used
- providing for efficient use being made of caught whales
- inspecting whaling operators
- collecting information about whaling and whales

Each country must provide government inspectors to see that its whalers obey the Commission's regulations. Since 1972, most whaling operations have also been watched by someone from a different member country.

At first the Commission gave total protection to the slow-swimming gray and right whales which had been the target of the early whalers and were quite rare. Then it set quotas for baleen whales in the Antarctic. These quotas were for 'blue whale units', based on the amount of oil that could be obtained from them. One blue whale was equivalent to 2 fin whales, 2.5 humpback whales or 6 sei whales. The Scientific Committee which advises the Commission said in 1964 that this system was inadequate because whalers concentrated on catching blue whales, whereas the intention was to spread the catch across several species. Blue whales soon became severely depleted and were protected by the Commission. Whalers turned to humpback and fin whales which quickly suffered the same depletion and required protection.

In 1974 a new way of setting quotas was worked out. The Scientific Committee has to assess the number of whales of each type in each area and work out how many of them can be safely caught.

The aim is to bring the numbers of each type of whale to a certain level and keep them there. Since



dwindling. Since whaling takes place in the open sea and many different countries were involved in it, an international regulating body was needed.

The International Whaling Commission

The International Whaling Commission has regulated whaling since 1948. Its powers come from an agreement among the 39 members. Nine member countries are still involved in whaling to some extent. These are Brazil, Chile, Iceland, Japan, Republic of Korea,

Monaco, Netherlands, New Zealand, Switzerland, UK, USA, Uruguay.

In the 1980-81 season, 13 995 whales were caught by the whaling members of the Commission. A small part of the catch of 3299 whales was also taken by people for their own consumption and the 34 whales caught in the USA were caught by Eskimo people living in Alaska. The rest of the whales were caught for commercial purposes.

The functions of the International Whaling Commis-

the new system started, the Commission has generally accepted the Scientific Committee's advice about quotas. Previously, scientific concern had been over-ridden by pressure from the whalers for higher quotas.

The new system has led to drastically reduced quotas. It has also led to protection of the sei, minke and Byrde's whales in certain oceans. The Commission can only set quotas by species and geographical area, it does not allocate portions of these to the different whaling countries. The countries work this out by agreement among themselves.

Many people believe that whaling should be totally prohibited. In some countries, such as Australia and USA, the strength of their protests has led the governments to adopt a policy that all whales should be protected and to prohibit whaling operations by their citizens and in their region. However, some countries oppose this view, so the International Whaling Commission plays an important role in assuring that whaling is strictly controlled.

Source: High School Law Program, CDC, Australia.

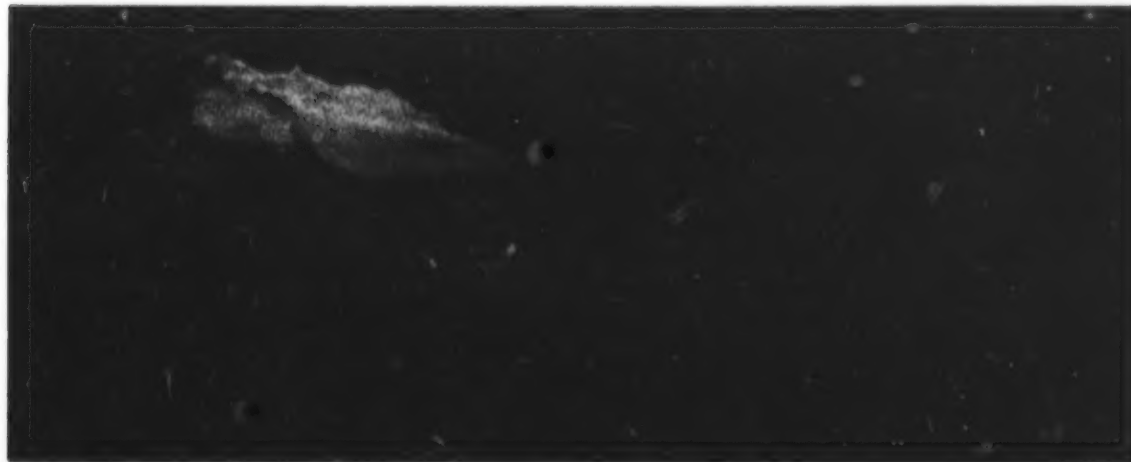
What Do You Think?

George Borgstrom, a Professor of Food Science, argues that what is needed is a policy not of **res**

communis (common property) but of **res nullius** (no man's property). To think through the implications of this issue ask yourselves the following questions:

- Should the 'super powers' with their sophisticated fishing equipment have the 'right' to take fish from any waters anywhere in the world?
- If they do have this right, should there be rules about how they use their catch (e.g. for human consumption instead of for pet food? Or for human consumption and for use in animal feed for stock to be ultimately used in human consumption? — i.e. poultry feed or cattle feed)?
- If restrictions are placed on how far from land various countries' fishing fleets can go, who should make the rules? By whom and how should the rules be policed?
- Should developed countries with complex fishing equipment be forced to share their resources with less fortunate nations? If so — how should sharing schemes be worked out? By whom? How will decisions about what is fair be worked out?
- How should traditional fishing rights be treated? For example, should the traditional rights of New Guinea Islanders take precedence over the new commercial agreements? Why or why not?

Russian trawler



A typical newspaper report indicating public concern about use of coastal seas.

Warning to Taiwan over 'poaching' in fishing zone

Taiwan was jeopardising its chances of gaining access to Australia's planned 200-mile fishing zone, the Minister for Primary Industry, Mr Sinclair, said yesterday.

The agents of Taiwanese interests negotiating for fishing rights should ensure that they were fully aware of the Australian attitude to "poaching".

Answering a question from Mr Humphreys (Lab, Qld), he said there were far more Taiwanese ships being caught poaching than any others.

"There are of course very real implications for any country that has been caught poaching", Mr Sinclair said.

"It will certainly be in our minds and any intrusions by a negotiating party will be taken seriously".

The Government was concerned at the increase in illegal clam fishing on the Barrier Reef in the past 12 months.

It was worried about the ecological damage that was occurring as a result. But most offending vessels were being apprehended.

The Government was ensuring that penalties were adequate, with fines and confiscation of ships in most cases.

"I hope there will be a reduction in the number of intrusions in the future", he said.

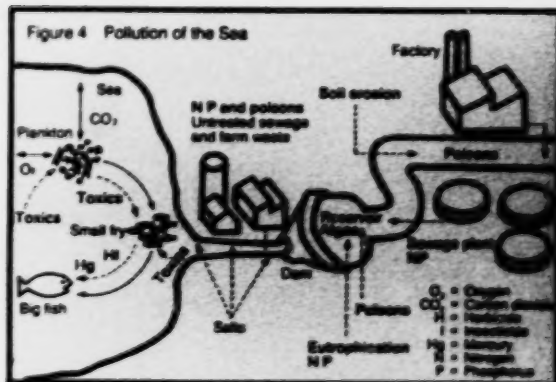
Canberra Times, 10 May, 1979.

3.0 Protecting the Ocean Environment: Pollution Control

Water pollution is one of the greatest threats to the future well-being of mankind. The pollution of inland waters is already a serious problem and the growing pollution of oceanic waters is causing increasing concern. A recent chemical test of the Pacific Ocean showed that parts of it contain 10 times as much lead as they should in nature. Where did it come from? How do pollutants enter the ocean?

Sources of Pollution

- inland rivers that flow to the seas
- off-shore dumping of wastes by coastal industrial plants
- boats discarding waste and the flushing out of oil tankers
- accidental oil spills
- fallout of particles from the air
- rain and snow
- animals migrating from other polluted waters
- currents coming from polluted areas



Two of the major sources of ocean pollution are

- oil spills
- the dumping by industry of poisonous waste material

3.1 Oil Spills

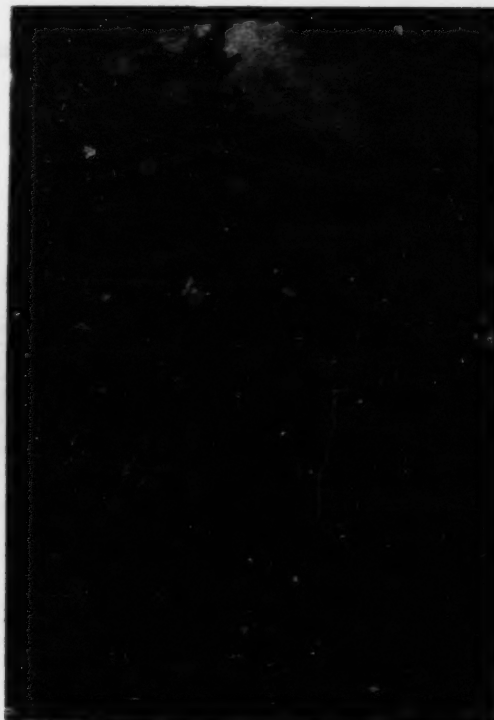
How would you like to swim on a beach where the water is covered in oil? When an oil tanker is wrecked, thousands of gallons of oil gush out and a thick layer of black sludge covers the coastal waters, and often the beaches, for miles and miles.

Every year, thousands of tonnes of oil are dumped in our oceans with 7 500 cases of oil spillage occurring annually. This comes from

- Oil tankers which are accidentally damaged or wrecked

- ships deliberately discharging waste oil into the sea as captains flush ship bilges and tanks with sea water
- accidental spillage at terminals where oil is pumped ashore from tankers
- leaks from underwater oil wells which are difficult to control.

Below left: Oil tanker breaking up and spilling tonnes of crude oil into the sea.
Below: Oil covered beach, a result of oil tanker spillage.



Spills have increased as petroleum-producing countries drill more offshore wells into continental shelves and new supertankers carry huge cargoes of oil. Along the coasts of the USA there are over 3 000 drilling platforms posing a threat of blowout in the offshore waters where most marine life is to be found. There are now over 4 000 oil tankers in the world and almost a billion tonnes of oil is transported across the oceans every year. An estimated 80 000 tonnes of indestructible tarry residues are floating on the ocean.

Why is Oil So Damaging?

Oil and water do not mix. As the oil floats on the water, it prevents sunlight from penetrating to the plant plankton that live near the surface. Without light the plant plankton die and the food supply for fish is reduced. This in turn reduces the food supply for humans.

That's not all. Many birds become coated with the oil from oil spills. An oil-soaked bird is a pathetic sight. The oil coated feathers are too heavy and the birds cannot fly. They drown. It's estimated that the oil spill from the tanker *Torrey Canyon*, in 1967 in the English Channel, destroyed 25 000 seabirds.

In 1969 there was a spill of fuel oil off Cape Cod on the eastern sea coast of the U.S.A. Immediately after the accident dead fish, crustacea and marine worms washed up into tidal pools. A year after the accident the waters looked clear, but when a local marine scientist tested the sediment from the ocean floor in that area, he found that oil was still present over large areas of the sea bottom. As well, the shellfish in this area still contained traces of harmful chemical elements from the oil, a possible public health hazard.

The wreck of the tanker *Tampico Maru* off Mexico in 1957 spilled 7 000 tonnes of heavy diesel oil and destroyed the entire marine population along two miles of coast. Some species began to return within two months but sea urchins and abalone were greatly reduced in number four years later. Ten years after the accident several forms of marine life had not returned.

What Can Be Done?

In the case of the *Torrey Canyon* spill in the

English Channel, the British Government tried using detergents to disperse the oil; the French used special chalk to sink it to the bottom. Unfortunately the detergents did as much harm to marine life as the oil, and the chalk just transferred the problem to the bottom of the sea.

Government and industry are seeking ways to clean up oil spills more effectively. At present the

standard clean up method is to use straw and sawdust to soak up the oil remains. The real answer however is **prevention**.

At the United Nations Law of the Sea Conference (still in session in 1982) coastal nations have got together and drawn up a list of draft proposals that they hope will eventually help to solve the problem (see Section 4).



3.2 Chemical Waste

The safe disposal of chemical waste is a serious problem in all the industrialised nations of the world. Did you know that **toxic metals** such as mercury and lead have been dumped into the seas by the world's industries? Fortunately this practice is now strictly controlled through an international convention and through the Intergovernmental Maritime Consultative Organisation (IMCO).

The DDT from **pesticides** has appeared in fish and animals in the most remote places — it has even been found in Antarctic penguins. Through runoff from the land it is estimated that about 25% of all DDT is in the ocean. Even if the use of DDT were stopped, its levels in fish would not decline for 20 years because of the slow process by which it is spread and absorbed into organisms.

Some of the worst chemical pollution is caused by factories built along shorelines. Below are some examples of what has happened in highly industrialised areas of coastline in Japan.

During recent decades the Japanese economy has grown very rapidly. Factories tend to be built near the coastline because land there is cheap and easy to obtain and because raw materials and finished products can be shipped in and out by sea. One by one, fishing villages are being replaced by smokey factories and as a result, Japan's seas are becoming more heavily polluted.

Often a company will buy fishing rights in an area from a village fishing community, offering to pay the equivalent of one to two years' earnings to each family. If the villagers are poor, in debt, or inex-

perienced in business, they may sell, thus enabling the company to fill in the area and build a plant. Pollution from the construction, and later from the plant, hurts fish in adjoining areas thereby enabling other companies to more easily buy up the fishing rights from other fishing communities nearby.

In this way, by 1973, 21.2% (5 650 km) of Japan's total coastline had been turned into factory land and closed to the people.

Many Japanese local fishing people have fought back against reclamation and pollution. One of the most famous struggles is that of the people of **Minamata**, in Kyūshū. There a fertiliser manufacturer called Chisso Company poisoned the fish by pumping organic mercury into the bay with its waste water. Hundreds of thousands of people who ate the fish became sick with 'Minamata Disease', suffering paralysis, blindness, and for hundreds, death. For decades the victims, mostly poor fishing people, have fought against the company to force it to accept responsibility and pay compensation to the victims. Their struggle first became publicly known when in November 1959 the fishing people invaded the factory, smashing equipment and trying to destroy the pipe that was sending poison into the sea. After that they began a long court battle. From the beginning the government supported Chisso in every way it could. Finally the courts decided that the company had actually caused the disease, and that it must pay compensation to the victims. But in the meantime Minamata Bay had become a lake of poison, and the number of victims had grown tremendously. The struggle still goes on today, with the Chisso Company and the government trying to reduce the number of recognised victims. The Minamata struggle is considered by many to be the most important movement of fishing people in Japan. This is because of both the terrifying nature of Minamata disease and because the struggle has seen people who are among the poorest and most neglected in Japan raise their voices.

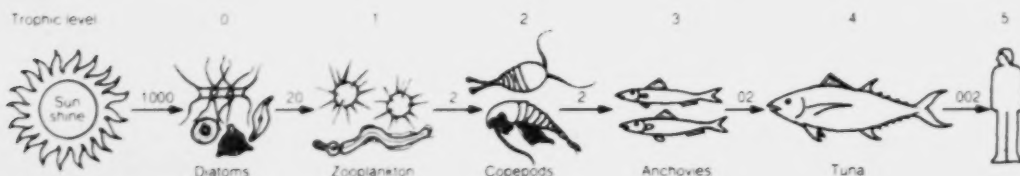
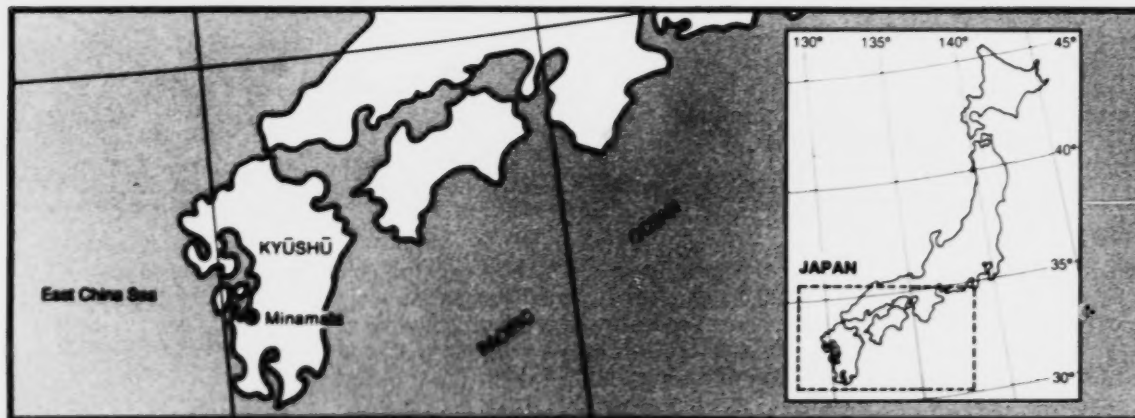


Figure 5. Illustration of the amount of energy being passed on to successive trophic levels from the original 1000 calories of solar energy used by the primary producers.



Source: Asian Action, November - December, 1978

3.3 The Battle for the Shorelines

As the case of Japan illustrates, the problem of chemical waste has turned into a battle for the shorelines between citizens and fishermen and big industry. In the U.S. state of Washington, a state that features magnificent shorelines, forests, lakes and rivers, the waterfronts are being bought up by corporations and land speculators. After a great deal of citizen protest a Shorelines Protection Bill was drawn up. It declared the saltwater and freshwater shores of the state a valuable natural resource to be held in public trust for all citizens and their descendants. Among other things, it forbade the clearing of timber along shores, oil drilling and exploration in the Puget Sound, and the construction of high-rise buildings that block the view of nearby residents. When the Bill was introduced into the state legislature it became bogged down in arguments and has still not been decided upon.

Meanwhile, to fishermen, some areas of shoreline will always be more important than others. For a citizen who lives on the coast, the most valued area of shoreline may be the most beautiful. The citizen will value it for the way it looks without knowing, or caring much, about its biological function. For the fisherman, the reverse is often true, as in the case of swamps, or estuaries.

3.3.1 Focus: Looking Ahead for Estuaries

Some of the most important areas of shoreline in every coastal country are its **estuaries**. Estuaries are the areas at the mouths of rivers where waters from the land meet those from the sea. They are vital to a nation's fishing industry. In Australia, for example, nearly one third of Australia's commercial fish are dependent at some stage of their life on estuarine areas.

The **estuary ecosystem** includes not only the waters of the estuary, and the seafloor under it, but also the rocky and sandy foreshores, mud and sand flats, seagrass beds, mangrove swamps and salt



Mangrove estuary

marshes of the inter-tidal zone, as well as the plants and animals of these different habitats.

Estuaries provide the food and shelter essential for the survival of large numbers of sea creatures, especially while they are young. **Seagrass beds** and **mangrove swamps** are especially important areas.

Not only do they provide shelter for young animals against strong ocean waves, but seagrass beds produce about 10 tonnes of dead plant material per acre each year, and mangrove swamps about four tonnes. That is a lot of food.

Most people view mangroves as just foul-smelling

swamps with hordes of unpleasant insects and such contorted, angled roots that it's almost impossible to climb over them. They find it difficult to believe that they could be such a valuable part of the estuarine ecosystems. In fact, mangroves are really tidal forests. They are stands of trees which can survive in the inter-tidal zones, with their roots covered at high tide by the brackish water of the estuary, and uncovered at low tide. Mangroves protect coasts from erosion.

When dead mangrove leaves fall into the water, they are colonised by huge quantities of minute bacteria and fungi. These in turn are eaten by one-celled animals called protozoans. This mixture of fungi, bacteria and protozoans on the decaying mangrove leaves forms about 80-90% of the food of many crabs, worms, insect larvae, shrimp and small fish. These are in turn eaten by the young forms of slightly larger fish, some of which will leave these protected areas when they are bigger. One hectare of mangrove swamp can yield up to 90 kilos of fresh fish each year. But in many areas mangroves are being cleared, and also used as dumping grounds for garbage.

The major damage to estuarine ecosystems is of two kinds:

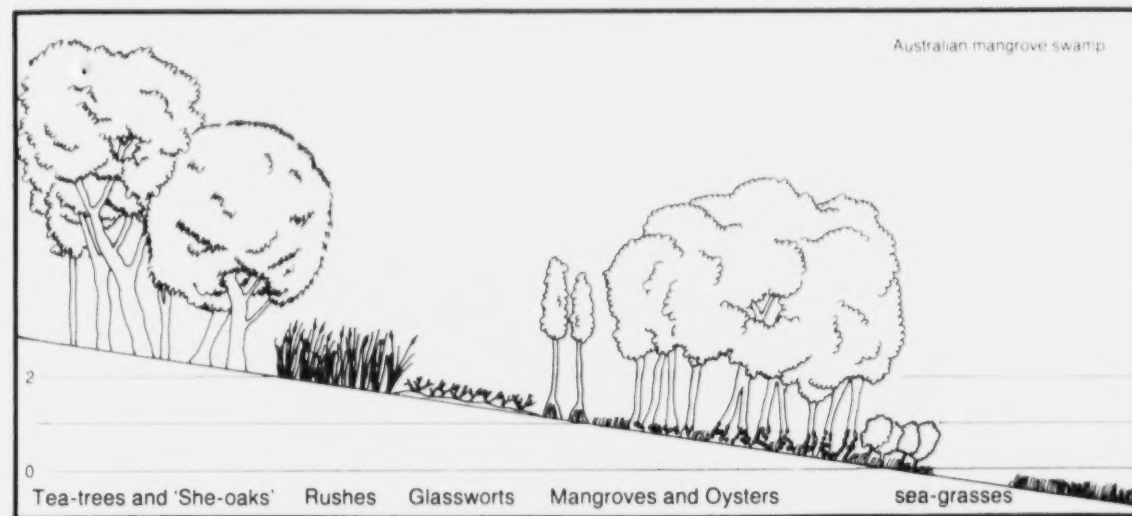
- changes to the physical environment of estuaries
- changes to the quality of water in the estuaries.

The Physical Environment.

We might sometimes think that physical changes such as reclaiming swamps, dredging shallow banks and building retaining walls are 'improvements'. But these often turn an estuary into little more than a drainage canal. Deepening an estuarine channel, for example, may improve it for yachting, but it might remove the shallow beds of seagrass necessary for food and shelter for estuarine animals. Real estate developers in many places exert pressure to extend existing built-up areas as ribbons along the shoreline, rather than spreading the development inland as well. They say that people like to live near the water, and will pay more for land with water views. This may be true, but the communities concerned will eventual-

ly have to weigh up the costs. Housing estates built on low-lying swamp areas mean that the area, along with its saltwater swamp and resident mangrove stands, is lost from the estuary system altogether. Should we be thinking instead of making estuarine areas accessible to all, rather than destroying them over the long term?

controls we could prevent further deterioration. We should remember that in the Everglades of Florida and the delta of the Mississippi River in the U.S.A., many millions of dollars are now being spent in trying to restore the estuary system, as near as possible, to its original condition — planning and control in earlier times would have saved this money.



Changes to Water Quality

Changes to the quality of water by pollution is the other main danger. The pollution comes from waste disposal and these wastes have a number of effects as we have seen.

Pollutants come not only from industry and sewerage outfalls but also from farming. When farmers use insecticides and herbicides on their crops, much of it gets washed away into the river system and ends up in the estuary system. A less obvious pollutant is heated water from thermal power stations: the heat kills many organisms and alters the behaviour of others.

Foreshore areas, such as mangrove swamps, have often been used as tips and garbage dumps.

There is also the question of damage that has not yet occurred. With careful planning and government

Figure 6 Wetland Vegetation



3.4 Fighting Back: The Kuala Juru Co-operative

Sometimes pollution damage to fishing grounds is so drastic that it alters an entire community — but not always for the worse. The following article describes a 'success story' and demonstrates how a small group of people have the power to effect change.

Kuala Juru is a small fishing village in Western Malaysia with a population of only 300. In 1976 chemical wastes started to pour uncontrollably into the Juru River, pushing the village economy to the edge of extinction. That Kuala Juru did not disappear beneath a morass of chemical pollution was entirely due to the unique and unexpected response of the village fishermen. For the first time in Malaysia, a village organised itself into a collective force both to face the pollution crisis and to salvage its future.

Misfortune first struck the village in 1968, when a bridge was built across the river, effectively retarding its flow and causing severe silting. Before long, the river, which had for hundreds of years been a reliable source of fish, crabs, prawns and lobster, became too shallow to support normal fish life. Then, during the 1970s development boom in Malaysia, the Prai Industrial Estate was built close by. Its waste products

went straight into the Juru River, which was transformed into a floating mass of foul-smelling, multi-coloured solids. Not surprisingly, the few remaining fish died.

Appeals to the press, strong letters of complaint and demands for compensation came to nothing. Finally, the few remaining fishermen decided to join forces and set up a co-operative, holding collective responsibility for their future.

The central activity of the Kuala Juru Co-operative became cockle farming, following the lucky discovery of large quantities of cockle 'seeds' in 1976. A license for breeding was granted and the village's first co-operative project was started. Cockles fortunately proved to be the right choice, taking only eight months to mature, providing a quick return on investments and having the advantage of greater resistance to chemical pollution than fish. The second cockle project was an undeniable success, producing 37 191 bags of cockles worth \$546 707. After deducting costs, an average monthly income of \$539 was obtained for each of the 81 participants.

Significantly, one third of all earnings is channelled

into a Village Fund to ensure the fullest development of the entire community, with an emphasis on social, educational and religious needs. The Fund is of course also used for new investment in future projects and the buying of essential cockle seeds. Perhaps the most dynamic use of funds has been the formation of a grocery and coffee shop. The coffee shop provides an important focal point for the community and, with the opening of a grocery store, villagers are no longer at the mercy of small monopolistic businesses.

According to the majority of villagers in Juru, the most important allocation of the Fund is the 11% contribution toward education. The aim is to provide supplementary and remedial education to help compensate for the 'crisis period' when income and morale were so low that many children stopped attending school. The Co-operative now has high hopes that some children will reach secondary levels and qualify for vocational training.

In addition to the Village Fund, the Co-operative also contributes 10 cents from every bag of cockles to two external organisations — The Consumers Association of Penang (CAP) and The Fishermen's Association of Seberang Perai. CAP's Rural Group, the villagers say, played a valuable role during the pollution crisis, advising the fishermen and highlighting their plight to the authorities and public alike. With the easing of difficulties, the Juru fishermen continue to support CAP as a gesture of appreciation to help raise the alarm for all innocent people victimized by ill-planned development and pollution.

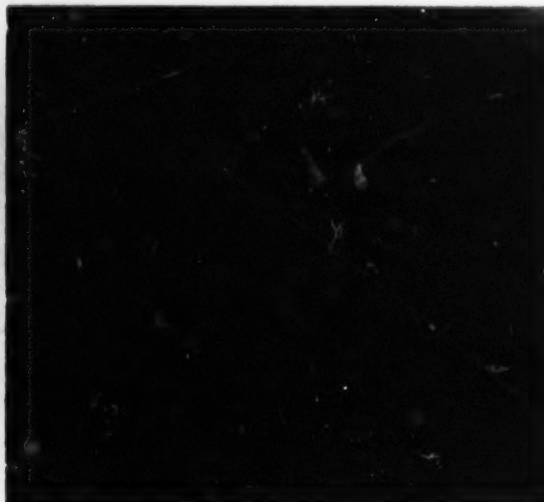
Already villages in the vicinity of Kuala Juru are considering the idea of forming co-operatives, and four have actually done so.

There are also indications that this trend is now spreading to other fishing communities along the entire west coast of the Malaysian peninsula. Apart from restoring vital prosperity, the experience of the Juru fishermen provides a valuable example to all other small communities facing the disruptive effects of pollution.

Source: Ceres, *FAO Review on Agriculture and Development*, May, June, 1981, p. 9-10.



Cockle



4.0 Fishery Management

So far in this book we have looked at ways in which we can

- establish a fair and reasonable law of the sea
- protect water from pollution.

These two things, however, are not in themselves enough to guarantee that we will make the most of our ocean resources and produce more food. They are the **pre-conditions** for good management.

A living natural resource such as trees or fish is not like a non-living one such as minerals. A mine has only a fixed quantity of minerals and they may be taken quickly or slowly, at the decision of the mine-owner. A population of fish will continually provide a harvest — every year for ever — if the harvest is kept within the capacity of the fish to reproduce themselves. The resource can be made to serve mankind indefinitely if:

- its capacity is understood;
- the harvest is regulated;
- the fishing is supervised to ensure the capacity and harvest **remain** balanced.

This is called the **conservation of resources**.

A population of fish of a particular species consists of a large number of individuals of varying ages (sizes) living within a defined area. In its natural state the total number of individuals remains stable. Although eggs hatch each breeding season, the numbers of young that survive (called **recruitment**) equals the number of mature adults dying and losses by predators, disease, etc. (called **natural mortality**).

The population however has a great capacity to expand its production of young in an emergency such as epidemic disease, or short term environmental change. This capacity has evolved by **adaptation**. Man's harvest of fish stocks is possible because of this facility. In normal times this capacity is not used but remains ready, in reserve, to combat any increase in mortality. Fishing, by removing animals from the population, can be treated as another form of mortality (**fishing mortality**).

Some species have a greater capacity than others to balance the added mortality and thus the first task

of a fisheries scientist is to obtain:

1. a reliable estimate of the size of the fish population;
2. a measure of the capacity of the fish population to respond to fishing mortality by
 - (a) improved growth of individual fish
 - (b) increased production and survival of young fish.

From this information a 'safe' level of catch can be determined which will ensure:

- (a) the population is not likely to be fished out;
- (b) the fishing industry will always continue;
- (c) the **optimum** harvest is taken for the benefit of mankind.

What do we mean when we talk about 'management'?

- a goal, or set of goals;
- a plan for achieving those goals, that is, a series of steps which will help us to achieve our goal.

In a good plan, these steps or stages have an **organised relationship** to one another — each stage grows out of the next in a logical way. We plan that A

will produce B which will in turn produce C and so on until we reach our goal.

Before we can draw up a management plan for anything, we have to be very sure just exactly what it is we want to do.

The goal of management should be chosen by the owners of the fish. As we have seen fish belong to no person but to the whole community. If this is so the community should determine the **management objective**. Usually the community does not directly undertake this work but it is done by the community's representative — the government. Where 'the community' involves more than one government, special arrangements such as commissions* may be appointed by the participating governments. This situation is often required to manage ocean-ranging species such as whales (International Whaling Commission) and tuna (Inter-American Tropical Tuna Commission).

*A commission is a special form of government committee set up to investigate or regulate a particular issue.



Jackass Morwong

A wide range of objectives (goals) have been selected by communities, for example:

- to provide maximum **employment**;
- to provide the largest safe harvest of fish for **food**;
- to generate the maximum **wealth** for the community.

Which do you think is appropriate for a fishery you know?

As fishing is a business, the management plans of most modern fisheries, i.e. in developed countries, aim to produce the **greatest value** of fish at the **lowest cost**.

Having chosen the goal the next step is to **develop** the plan.

Step 1

Decide over what **area of the ocean** the management will operate. The area is affected mainly by the distribution of fish and fishing boats, and also the limits of the authority of the government or commission.

Step 2

Collect information on the biology of the fish, the quantity and the age of fish being caught, and the amount of fishing needed to take the catch.

Step 3

- What does this information mean?
- Are too many fish being caught?
- How big a catch is safe?
- What will happen if more vessels begin fishing?
- Should the catch consist of fish of a different size?

Step 4

Consider what **controls** would be applied to the fishing fleet. Which are most likely to help in achieving the chosen goal?

- Would banning the capture of small fish help?
- Would limiting fishing to a short season help?
- Would restrictions on fishing gear help?
e.g. the length, depth, mesh size of nets;
the size of traps;
the number of hooks used on a longline.



- Should the number of fishing boats allowed to catch a particular species be limited?
- Should licence fees be very high to discourage fishing?
- Should a fisherman be allowed to take only a fixed weight of fish — a quota?
- Would limiting the total catch to a known amount be enough?

These and many other fishing regulations are used throughout the world.

Step 5

Select the best controls: this requires discussion between the government or commission and the fishermen. It must not only result in the management objective being reached but be within the capacity of the management authority to put into effect. It must also be acceptable and practical from the fishermen's point of view.

The **cost** of the controls should also be considered. An effective but very expensive system may be beyond the capacity of a small community to pay. Community taxes must pay for many services.

Step 6

Begin the controls:

- by agreement with fishermen;
- by law;
- by international conventions.

Step 7

Check that the rules are being followed.

Step 8

Do the controls work? Is the objective being achieved?

- Collect more information.

If the controls are not working, change the management plan by selecting new controls or altering the existing ones.

In order to appreciate the practical problems associated with fisheries management let us examine the fishery for southern bluefin tuna in the south west Pacific and Indian Oceans which is described in Section 2.1 of Book 2.

4.1 State of the Southern Bluefin Tuna Population

Southern bluefin tuna is a highly migratory species. It spawns during the period September to March. The area and period of reproduction presumably change slightly from year to year due to the variability in oceanographic conditions. Most of the juveniles migrate to the seas off Australia passing Western and South Australia, Victoria, and New South Wales.

At this time, they become subject to the Australian fishery. This fishery operates on surface southern bluefin tuna schools. The average age of tuna caught in each area is indicated in Figure 7. Obviously, this general pattern is a simplification of the actual picture since the ages of fish caught in each area are distributed around these average, or 'mean' ages.

After leaving the Australian fishery they are sought by the Japanese longliners

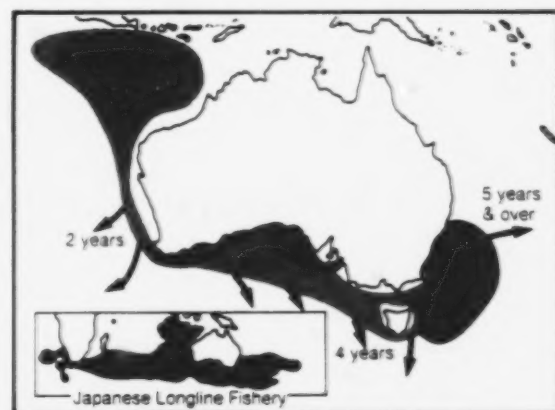


Figure 7 Southern bluefin tuna spawning area and migration pattern off Australia (shown in light grey). The operation areas of the Australian fishery are shown in dark grey. Arrows indicate the direction of fish escapement from the 200-mile Australian Fishing Zone. A map of the operation area of the Japanese longline fishery is enclosed. All mentioned areas change slightly from year to year; the marked ones represent the average situation.

Until 1975 the stock of southern bluefin tuna had been fished principally by Japan and Australia with some Korean vessels participating in the Japanese segment.

This may be because the species has little contact with the coastline of other countries. The countries with which southern bluefin does have contact are those which have contact with the West Wind Drift — Argentina, South Africa, Australia, New Zealand and Chile. Among these countries, the ones satisfying the conditions for the development of shore-based surface fisheries for small southern bluefin are: first Australia, then New Zealand and South Africa.

On the other hand, in Japan, the tuna fisheries have developed as far seas fisheries. Therefore the southern bluefin stock has become the object of exploitation though the stock is located far from Japan. The reason why the fishing by the Japanese has been intensified is that the species is used for high class 'sashimi', sliced raw tuna, a traditional Japanese dish. Furthermore, the demand for it has grown due to the rapid economic growth of Japan.

Since 1975 New Zealand has developed a fishery and the declaration of 200 mile fisheries zones brings other countries into the situation in one or more of the following ways:

- as actual or potential fishermen;
- as a manager of portion of the stock in accordance with the proposed new Law of the Sea;
- as partners with one of the fishing countries in joint fishing ventures.

4.1.1 The History of the Fishery

The fishery began in Australia where in 1938 fishermen began taking the fish by trolling off eastern Tasmania — towing a single hook on a short line at about five knots. The fish were canned — following the American practice. After World War II the tuna were found to be off New South Wales and in the early 1950s off South Australia. These tuna were juveniles — 3-5 years old and occurred in schools and were attracted to water at a temperature of around 18-19°C. Fishermen looked for this water and used aeroplanes to search for the schools. Later the

aircraft were equipped to measure water temperature — now satellites are used.

In the early 1970s a small number of purse seiners were licensed to join the fishery. Since the mid 1970s the Australian vessels have increased in size and can now fish up to 350 miles from shore taking larger fish and directly competing with the Japanese, though juveniles are still predominant in the catch.

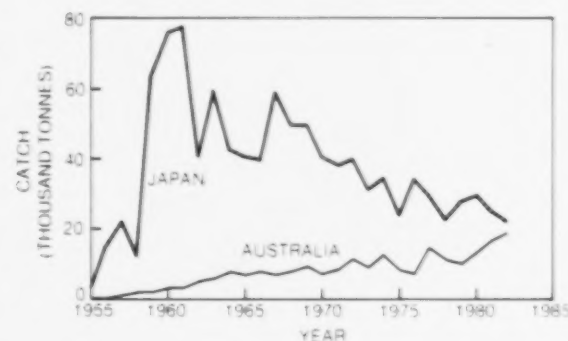


Figure 8 History of the Australian and Japanese catches (by weight).

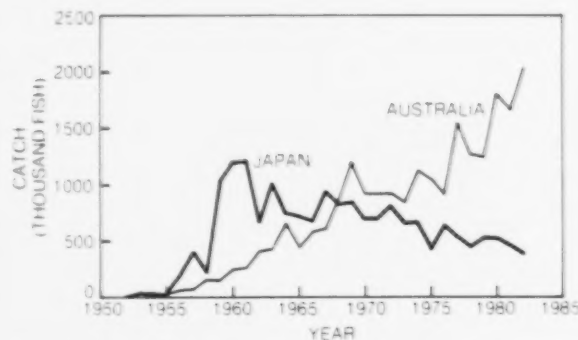


Figure 9 History of the Australian and Japanese catches (by number of fish).



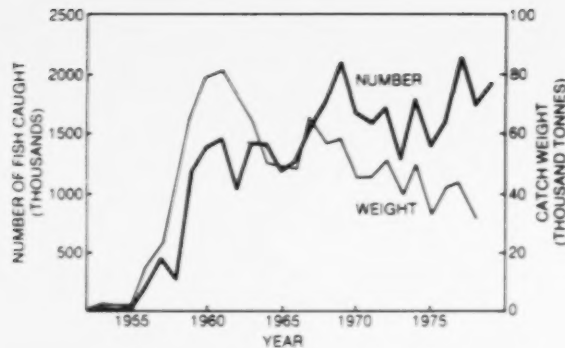


Figure 10: History of the total catch.

The exploitation of this species by the Japanese began in 1952 with fishing in the Indian Ocean off north western Australia. Their market is for large adult fish which rarely school like the juveniles so they must be sought over the whole ocean. The Japanese have developed the longline method for this purpose (See Book 2, Section 2.1).

Figures 8, 9 and 10 show the changes in catch of the Australian and Japanese fishermen and the total.

4.1.2 The State of the Population

Considerable research has been carried out on this fishery by scientists in Japan and Australia. Fish have been tagged as juveniles off south western Australia and subsequent recoveries from the catch recorded. The number of fish caught for each unit of fishing effort (e.g. per thousand longline hook sets) is also calculated as this is proportional to the relative density of fish on the fishing grounds.

The scientists conclude that:

1. The stocks of fish are fully exploited — that is even by fishing harder (increasing fishing effort) there would be no sustained increase in catch.
2. Future catches may be reduced because the declining number of mature fish capable of spawning (see Figures 11 and 12) may cause declines in recruitment.

3. The risk of the future of this fishery is relatively high, in comparison to other fish species because the resource is extremely valuable and the high price paid to fishermen encourages them to continue to fish even though catch rates fall to very low levels. (With a less valuable species economic pressures would force the fishermen to halt fishing before the population was reduced to a dangerously low level. Can you explain why?)

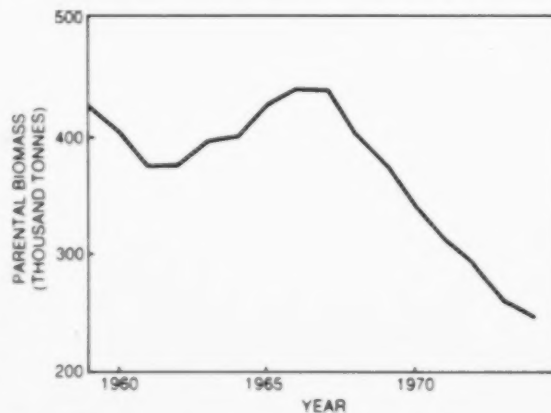


Figure 11: Time changeability of the spawning biomass* (each year in January) estimated on the basis of cohort analysis.*

*biomass — the amount of living matter in any given habitat, usually measured by the weight of organisms per unit area.

*cohort analysis — the method of examining a population for the occurrence of age and or size groups.

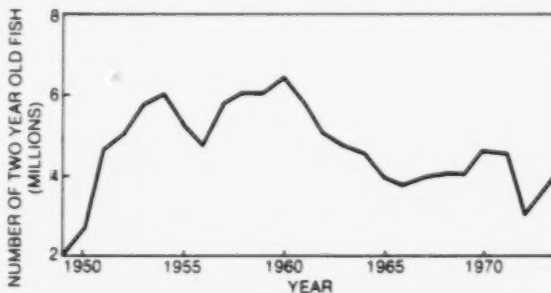


Figure 12: Change of the number of recruits to the global stock (the number of fish at age two years old) estimated on the basis of cohort analysis.

4.1.3 Developing a Management Plan for the Fishery

Who controls the fishery?

The immediate answer to this question is no-one, certainly no one country. Several countries are responsible now that the 200 mile fishing zone is accepted as international law — these are the countries whose zone is inhabited by the species. But some of these countries do not directly fish for southern bluefin tuna — should they play a role equal to Australia and Japan?

Determining the answer to this question is one of the major problems to be solved before management can be effective. Clearly some form of international body is needed but what countries should participate and on what basis is not so obvious.

The major fishermen naturally feel that they are entitled to the major 'say' in management. Are they?

What should be the area to be managed? Should it be the total distribution of the species, or the area used by the commercial fishery? Should the area include the waters within 200 mile fishing zones?

What should be the objective of management?

The proposed text of the new Law of the Sea suggests that fisheries should be managed to achieve the optimum yield.

The attractiveness of this term is that it can be interpreted to cover a range of objectives. In this fishery, reaching international agreement on the optimum yield may also be difficult. Figures 11 and 12 suggest that it may be below the present catch. If so, how can the development goals of countries like New Zealand, and possibly others, be accommodated? Unless the requirements of all the countries who have the capacity to exploit the resource are met it is likely that they will ignore the management plan and go their own way. There is no all-powerful international fisheries policeman.

What controls are most likely to achieve the optimum yield?

Various options are available:

1. **Limiting the catch** would reduce the risk of over-fishing. If this were done directly by imposing a **quota** this would probably need to be divided up between the fishing countries — but on what basis? If a country received a quota, that country would then need to consider the effect of a quota on its industry.
How do you think this might affect
 - (a) existing fishermen?
 - (b) young fishermen just entering the fisheries?
 - (c) those people who may be planning to become tuna fishermen, including sons of fishermen?
 - (d) tuna canneries?
 - (e) ship builders, etc.?
2. The **protection** of small or large fish may help but Australian fishermen are largely confined to small fish particularly those in Western Australia.
3. If the **number of fishing vessels** were **reduced** then the catch would also fall if the reduction were large enough. More importantly the economic returns from the resource and for each fisherman would be improved. However the difficulties are similar to those with quotas.

The Japanese have imposed **voluntary controls** (closing areas to fishing) on their own fishermen since 1971. Both Australia and New Zealand impose restrictions on the Japanese in their 200 mile zones. This is largely directed at keeping the longliners away from their own fishermen whose activities are developing. (Figure 10 shows that the increase in the Australian catch has largely been at the expense of the Japanese.) Australia is considering the introduction of **minimum weight** in order to reduce the capture of very young fish. Scientists have calculated that the maximum yield from the population would increase if the youngest age group of fish in the catch were older.

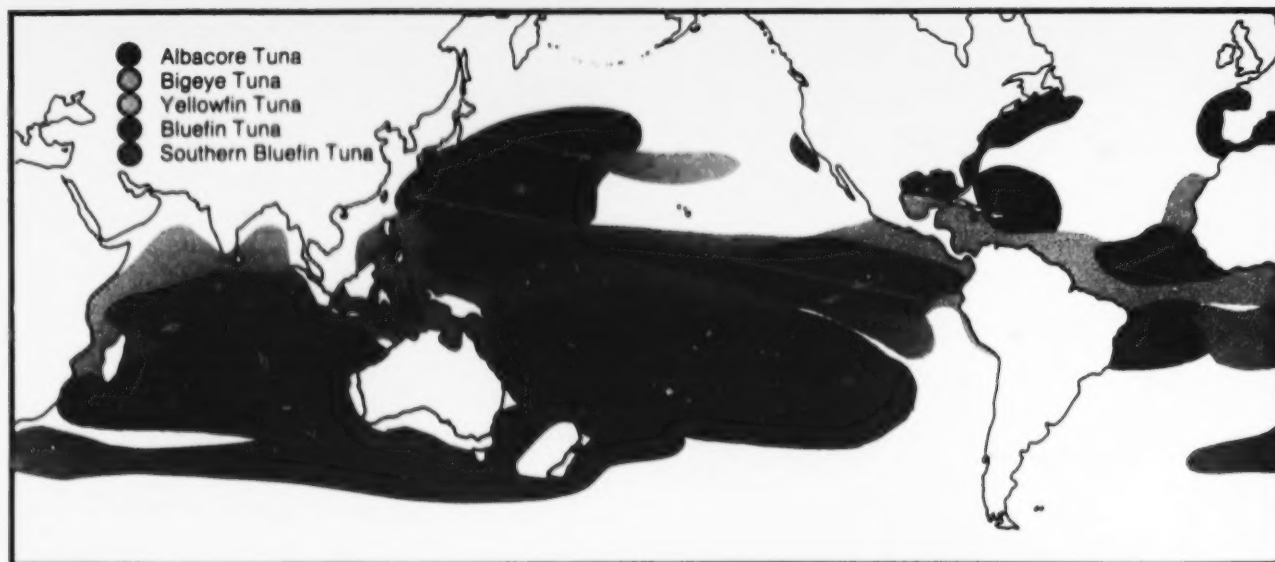


Figure 13a: Schematic diagram of chief distribution areas of tuna species.

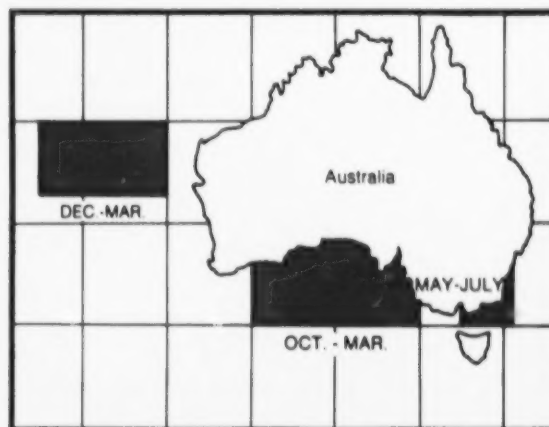


Figure 13b: Areas and periods of the southern bluefin fishing grounds closed by voluntary restrictions.

Source: Garth Murphy and Jacek Majkowski, *Australian Fisheries*, November 1981.



Poling tuna

4.2 Ecosystem Management

As we saw in Book I, Section 2.5 all species form part of an inter-related web called an ecosystem. Because the components in the ecosystem are so linked alterations in the population of one species will have an effect on others.

The harvesting of commercial species must have some effect on other components of its ecosystem. However there are not very many documented cases of this occurring. Why is this so? The principal reason is the complexity of the food web and the wide variety of species which form the prey of any predator. A sample of stomachs of juvenile tuna was found to contain 23 species of fish, five species of molluscs (squid and octopus), three species of crustacea and several other planktonic animals. It is also possible that insufficient research has been done to measure real changes that have occurred.

Nevertheless when developing new fisheries, especially those based on animals low in the food pyramid such as krill, the likely impact on other species should be examined. Traditionally fishing has been for the predators, towards the top of the pyramid.

Where it is intended to develop new fisheries based on key components in low trophic levels, like krill, the effects on other predators of krill must be considered.

4.2.1 A New Resource — Krill

What is krill? the krill is a small, shrimp-like form of plankton that lives in the Southern Ocean and occurs in astonishingly dense swarms near the ocean surface.

As we saw in Section 1.0, many marine scientists feel that large-scale krill fishing could be one of the solutions to the world nutrition problem, perhaps even doubling the current fish catch.

Estimates of the total weight of krill living in the Southern Ocean vary but probably exceed 400 million tonnes. Of this standing stock over 200 million tonnes is produced each year. This production is currently consumed by predators in the ecosystem

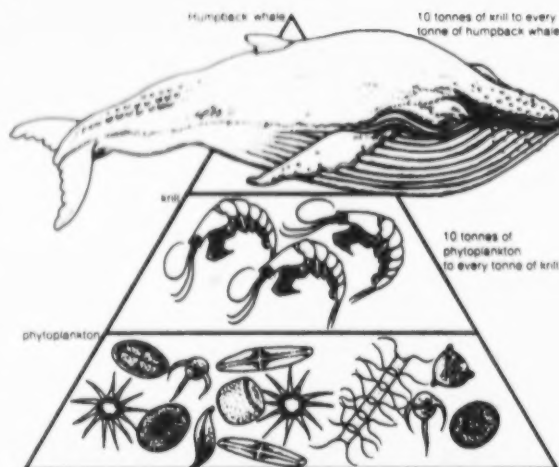


Figure 14: Food pyramid of baleen whale.

such as seals (about 64 million tonnes), whales (43 million tonnes), birds (about 15 million tonnes) and a significant but unknown amount by fish and squid.

If fishermen enter the ecosystem as another predator their share of the krill production must come from that now consumed by the other predators. What will be the net effect?

That depends largely on two factors:

- the capacity of other predators to feed on other zooplankton,
- the size of man's harvest.

If krill numbers are reduced and they therefore consume less of the phytoplankton crop, other plant eating zooplankton will increase. Figure 15 shows that as man reduces the population of krill-feeding whales other krill predators increase. Predators now feeding on krill will switch their eating habits to other zooplankton.

Nevertheless the population of the predators is expected to decline. How far should we allow the decline to go? Certainly not so far as would threaten the existence of the species or the stability of the ecosystem. Some conservation groups however, suggest that these predators should be maintained at

higher levels, perhaps at the level they were before man first entered the ecosystem to harvest whales and fur seals. In practice it is likely that the management objective will aim to maintain the krill predators at some reasonable fraction of this original level. Safe catches must not rise above this level in order to ensure the conservation of the stock.

Figure 15: Estimates of the amounts of krill eaten by predators annually.

	(millions of tonnes)
whales	43
seals	64
birds	15-20
squid	100
fish	?
total	more than 200



Figure 16: Where concentrations of Antarctic krill are found.

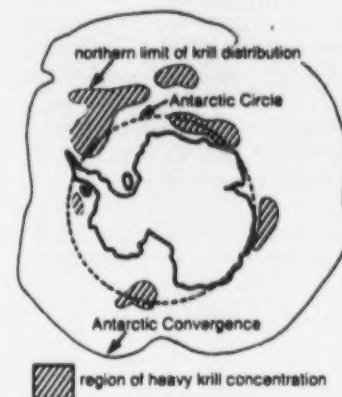
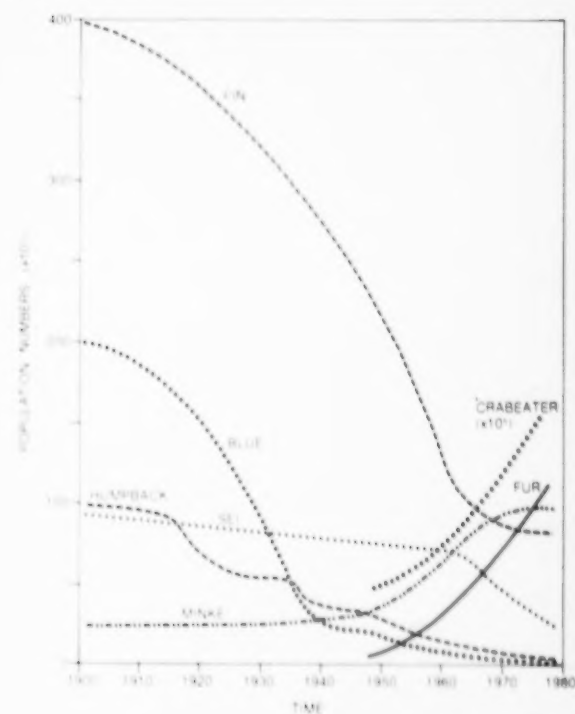


Figure 17 Estimated population curves of the major mammals in the Southern Ocean



Krill



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Seal



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4.2.2 Developing a Plan for the Wise Use of Krill

If it is necessary to restrict the catch of krill to meet the objectives discussed above will the demand for krill be satisfied by such a catch? At least in the short term we can confidently answer, yes. A sustained yield of 50-70 million tonnes of krill per year is possible — the demand, for the rest of this century at least, will be much less.

Likely Commercial Exploitation

Experimental fishing since 1969 has shown that krill can be caught sometimes in large quantities. Three hundred tonnes per vessel day is considered good.

Trawling in midwater is the best method and vessels of the U.S.S.R. have had success in towing a large midwater trawl between two vessels. Because the krill is small (3-5 cms long) the mesh size must be small and this produces great water resistance to the nets. Thus, very powerful vessels are required and costs are correspondingly high.

Latest total catch figures refer to 1977 when less than 30 003 000 tonnes were caught, about half by vessels of U.S.S.R. and a third by the Japanese. The remainder was shared by other countries including Poland and West Germany.

A range of products have been produced such as:

- whole krill boiled and frozen;
- krill tail meat, frozen within 1-2 hours of catching;
- minced tail meat which can be reconstituted into products such as krill sticks
- krill protein concentrate (KPC); a deodorised and fat free protein concentrate powder which is available as a food additive
- krill meat, for poultry and stock feed

To date none of these products have been on the market for long enough, or in sufficient quantity, for us to be able to assess whether or not they are acceptable to consumers. There is a further problem. The processing of krill products is complex and time-consuming and therefore the cost of production is high. Where production costs are high, then the price we pay for the product in the shops is likely

to be high and therefore unattractive. This could limit sales to the extent that it is not worth while to harvest the fish. Despite these problems the Japanese, in particular, are optimistic about the future of krill.

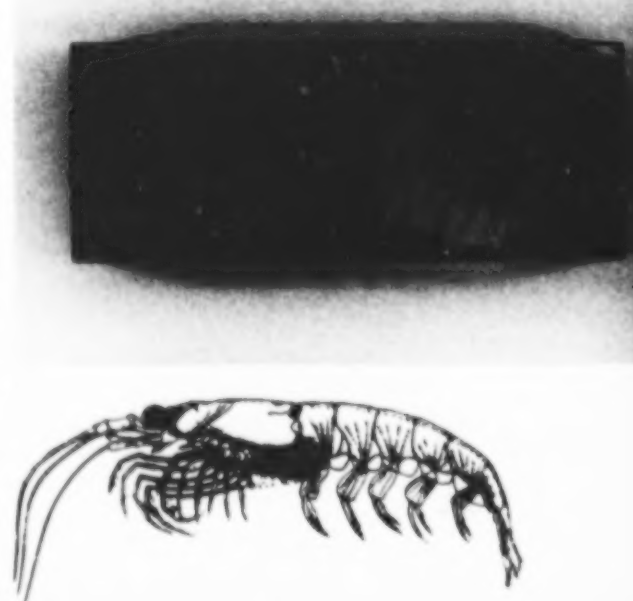
Summary and Conclusions on the Harvesting and Marketing of Krill

1. The general conclusion of the harvesting and marketing section is that, apart from a few specialist, high-value, low-volume products — e.g. whole krill, tail meats and surimi (a kind of Japanese fish paste) — the extensive use of krill by the world's economies is unlikely given current technology.
2. Krill appear to have no special property (e.g. taste or cheapness) on which a new or large market could be developed. (Compare with oysters or lobster.)
3. The large-scale development of this fishery will depend upon favourable movements in relative costs and prices, in comparison with other fisheries. Also, investors would have to be able to be guaranteed secure markets for large amounts of krill to justify the scale of investment required. (Remember, krill fishing requires large, expensive boats that travel long distances with high fuel costs. Because of the size and shell of the krill it is at present complex and time-consuming to process. See point 1 above.) There will need to be dramatic improvements relative to developments in other fisheries in the technologies associated with the catching and processing of krill.
4. If such prospects as outlined in 3 seem remote today, then clearly the long-term picture does not favour the extensive direct utilisation of krill. Some fisheries people argue that the commercial success of salmon ranching in South America or the resumption of whaling, once the large whales have recovered to optimum economic yield levels, may be more economically efficient.
5. In terms of its impact on the ecosystem, it appears that man's exploitation of krill will only be a serious threat if large-scale krill meal production begins.

6. At present, it does not appear that krill can be considered as a source of abundant food.

The case of krill clearly demonstrates that the exploitation of the resources of the sea must be considered as a business and managed on that basis. Even though up to 50 million tonnes of krill are available annually and techniques are available for its harvest and conversion into edible products — there will be no fishery until the consumer is prepared to pay more than the cost of production. Very rapid development is not likely and now that the international Convention for the Conservation of Antarctic Marine Living Resources has been ratified there should be adequate time for the development of a management plan that will rationally exploit the resource and safeguard the position of the other members of the ecosystem.

Krill sticks — *Euphausia superba* made into frozen fish fingers
a product of Chile



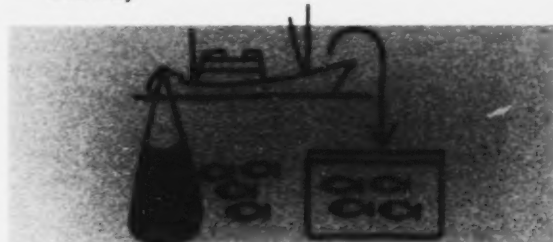
4.3 Aquaculture — the Protein Producer of the Future?

About 10% of all fish consumed in the world today comes from aquaculture, otherwise known as farming the sea (or fresh water).

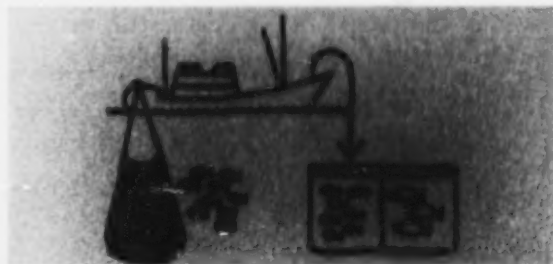
Because some fish stocks are declining and rising fuel costs are making long fishing trips more and more expensive, it makes sense for some fishermen to stay at home and look at ways of growing fish in their own waters — to become farmers of the sea instead of hunters, even though at the moment, the cost of farming fish is much higher than the cost of harvesting wild stocks. These fishermen are experimenting for the future.

There are four main types of fish farming.

1. Fish may be caught at a good size and held alive until it is a suitable time to sell them (when prices are high). Crabs and lobsters are often kept in this way.



2. Fish may be caught as fry (young fish) and reared to large size. This is common practice with milkfish, which are raised in brackish waters in many Asian countries, and also with eels in Japan, and prawns in Asia.



3. Fry may be produced by captive adults and set free into the natural environment where, it is hoped, they will be caught as adults. This is a method used for farming salmon in Alaska, Japan and New Zealand. The fish farmers know that in this case, salmon will return to spawn to the streams they knew when they were young.



4. Fish may spend their whole life cycle in captivity. For this to succeed, fishermen must know what the larval (very young) stage of fish eats, as this is often different from its later food. Increased scientific research and understanding has made for experimentation with a wide variety of species. Carp and trout are the two major species which have long histories of living totally in captivity.



For species where the breeding stage is in captivity, it has been possible to carry out processes of selective breeding to strengthen certain desirable characteristics, in much the same way as domesticated land animals such as the sheep, the horse and the cow, have been bred to produce certain features.

These methods are being used more and more in Asian countries where there is a shortage of protein. For example, in China the portion of the total national fish production is reported to be 40%, in India 38% and in Indonesia 22%. This is compared to Western countries where the amount of fish produced by aquaculture averages out at around one percent.

Squid produced by Aquaculture



4.3.1 Fin Fish

The Chinese have cultivated the **carp** for between 3000 and 4000 years. Europeans have cultivated carp for about 600 years. Besides a readily available and secure supply, aquaculture offers the opportunity of improving certain characteristics of species through **breeding**.

The Chinese have bred carp for characteristics such as a small head, high body, thick back, resistance to disease, suitability to different waters and

number of scales (the fewer the scales, the easier to prepare for cooking).

Carp are usually kept in ponds and often kept in **polycultures** — several types of carp together. Because different species feed from different parts of the pond (bottom, plants, top) they use the entire pond environment. In this way the fish farmer can make the most of the food resources available in any one water environment.

Trout is another fin fish which has been successfully bred in captivity. Young hatchery trout are often

put into inland lakes and waterways to boost natural supplies, as trout are a favorite of the sporting fisherman.

Mullet, milkfish and eel have all been cultivated in brackish water, in marshes and near estuaries.

Cultivating marine fish (**mariculture**) is relatively new. **Yellowtail** is the only marine species farmed on a commercially important basis, and this is in Japan. About 100 000 tonnes are produced each year. Experiments with tuna and salmon are also underway in Japan.

Trout from a hatchery



4.3.2 Shellfish

Oyster farming is one of the most popular and successful forms of aquaculture. Oyster 'farms' are usually in shallow bays where the oysters are set out on trays and sticks (in Australia) or strung on wires which are suspended from wooden or bamboo rafts which are suspended from wooden or bamboo rafts (in Japan). With raft culture the rafts are buoyed by floats. The wires usually extend to a depth of 10-15 metres and a typical raft is about 20 x 25 metres.

Mussels, scallops, abalone and prawns are also being farmed.

Scallops



Abalone



Oyster 'farm'

4.3.3 Seaweed

More than one million tonnes of seaweed per year is harvested from aquaculture, the bulk of it in Japan. The rest of the seaweed used is collected from what is washed up on the shore after heavy seas — but only used if it is very fresh. Seaweed is also collected from where it grows, either between the high and low tide marks, or below the ocean surface.

Many different types of seaweed are cultivated. The ancient Hawaiian nobility used to keep gardens of limu or seaweed, so that a variety of fresh sea plants was available for eating at all times.

Seaweeds are high in **food value** — they are among the world's most nutritious plants. They generally contain good quantities of vitamins, protein, carbohydrate, minerals, some fats and oils and trace elements. Over 70 types of seaweeds are used for food in Asian countries.

Drying seaweed



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Kelp

62

4.4 Finding Alternative Products

There is one other management strategy that deserves consideration here. When a traditional food source (for example, whales) is threatened by over-fishing, we can investigate other sources of food; for example, the small, shrimp-like crustacean, the Antarctic krill (see Section 4.2.1).

But the whale has been used, not only as a source of food, but as a source of many commercial products, such as soap and industrial machine oils. Here too, good management of endangered resources will consider the alternatives. The table below sets out some examples. It is followed by a section on the jojoba plant (its scientific name is *Simmondsia chinensis*) which looks at a promising substitute for the multi-purpose sperm oil that is at present extracted from the blubber of sperm whales.

Alternative Products

Essential Products	Whale By-Product	Possible Alternatives
Crayons & Pencils	Sperm oil, Spermaceti & Whale oil	<i>Simmondsia</i> wax
Fertilisers	Whale bone	Seaweed, various organic materials, composted material
Floor Coverings (linoleum & oilcloth)	Sperm oil & Whale Oil	Linseed oil, <i>Simmondsia</i> oil
Glycerine	Whale oil	Any saponified* oil or fat, e.g. palm oil, ground nut oil
Gelatine	Skin, bones & tendons	Skin, bones, tendons & hooves of cattle, sheep, goats, etc.
Margarine	Whale Oil	Vegetable oils such as ground nut oil, soya bean oil, sesame oil, maize oil, safflower oil, coconut oil
Vitamin A	Whale liver	Natural carotene from carrots & alfalfa; cod liver oil or synthesized Vitamin A from lemongrass oil or turpentine
Cosmetics: lipsticks etc., cold creams	Sperm oil and spermaceti	Essential oils such as lemon, orange, etc., <i>Simmondsia</i> oil, avocado cream, cactus cream, cucumber milk
Perfumes	Ambergris	'Fixateur 404', other fixatives based on labdanum, oak moss, clary sage, cypress oils, agar wood oil, etc.
Pet Foods	Whale meat	Fungal protein, abattoir waste, offal, cereal, protein, soya bean meal

*Saponification: The conversion of a fat into a soap by the addition of an alkaline substance. This liberates the remaining constituent of the fat — glycerine



4.4.1 Jojoba — A Future Oil Crop?

One of the most sought-after products of the whaling industry is sperm oil, taken from the blubber and head cavities of sperm whales. Its main use is in specialized lubricants for differentials in vehicles, and other applications where pressures are high. Before the United States Government banned imports of whale products in December 1970, it established a stockpile of sperm oil in case an emergency use arose for which no substitute was adequate.

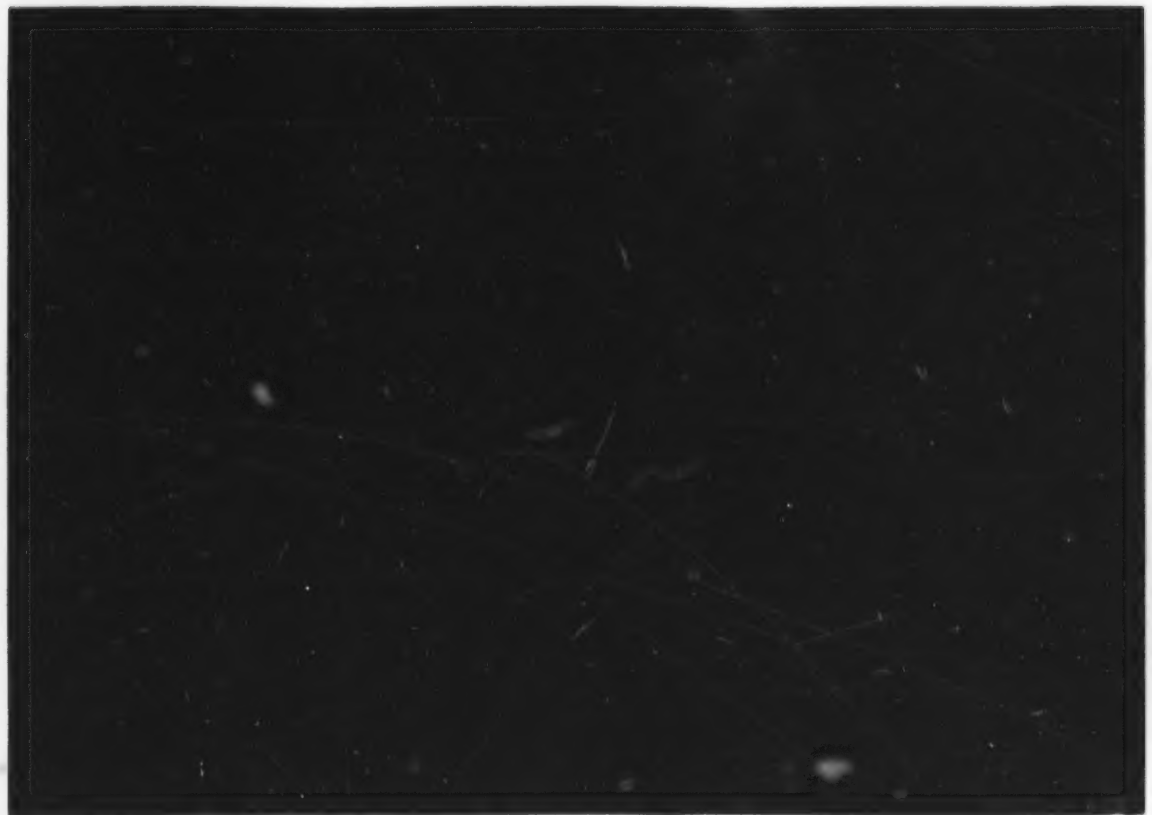
In the late 1960s, interest revived in an earlier discovery that a liquid wax could be extracted from the acorn-like fruit of a desert shrub of the American west, the much-publicised jojoba (pronounced ho-ho-ba). Just as the sperm whale is the only producer of this type of oil among animals, jojoba is the only plant known to produce a liquid wax. And its product is very similar to sperm oil.

Tests in the United States indicate that jojoba oil could be substituted for the whale product in virtually all, if not all, its uses. These include, apart from lubricants, wax goods such as polishes and candles, cosmetics, and various pharmaceutical products.

Jojoba oil has some distinct advantages over sperm oil, and may well find many new applications if large quantities become available at a competitive price. Unlike sperm oil, it contains remarkably small amounts of impurities and is very homogeneous in chemical composition. Another advantage is its lack of odour.

The problem at present, however, is that only very small quantities are being produced. Trial plantings of jojoba bushes began about 15 years ago, mainly in the United States, Israel, and Mexico, and some commercial plantations have now been laid out. But even if yields are as high as the planters hope, it will be many years before commercially significant quantities of oil become available.

In Australia, State government bodies, CSIRO*, farmers, and entrepreneurs have set up trial plantations in most States in the past two years. The bushes are being tested in many different environments. Since 1976, CSIRO's Division of Plant Industry has



Jojoba crop

established plantations at thirteen locations ranging from Moomba in the South Australian desert to subtropical Murwillumbah near the northern New South Wales coast.

Although jojoba is found in the wild only in arid areas, it may quite possibly perform better in a milder, moister climate. Wheat is a notable example of an arid zone native successfully cropped in gentler environments.

However, at present we don't know where jojoba will grow most productively in Australia, or even whether it will yield satisfactorily in any areas. And it will be up to 10 years before the planting trials begin to give firm answers.

*CSIRO is the Commonwealth Scientific and Industrial Research Organization.

Source: *Ecos*, CSIRO Environmental Research, 19 February 1979.



Glossary of Terms

arable	Fit for ploughing or tilling	estuary	An area at the mouth of a river where waters from the land meet those of the sea
aquaculture	The practice of farming plants and animals in water	Exclusive Economic Zone	An area of up to 200 nautical miles from the coast, recognised by international convention as being under the control of the bordering nation
biomass	The amount of living matter in any given habitat, usually measured by the weight of organisms per unit area, or by the volume of organisms per unit volume of habitat	FAO	Food and Agriculture Organisation, a subsidiary of the United Nations
brackish	Of salinity less than that of sea water, resulting from the mixture of fresh and salt waters	herbicide	A chemical preparation or other agent for destroying or inhibiting the growth of weeds, herbs, or other vegetation
cockle	A small bivalve mollusc	High Seas	A term in International Law referring to the open waters of the ocean not within the jurisdiction of any one nation
cohort analysis	The method of estimating size of a population by examining how the numbers of fish of different ages in it change as a result of catches over a period of years	insecticide	A substance or preparation used for killing insects
commission	A special form of government or international committee set up to investigate or regulate a particular issue, e.g. International Whaling Commission	Internal Waters	A term in International Law referring to waters substantially surrounded by the land territory of a nation, e.g. Port Phillip Bay, Chesapeake Bay
conservation	The act of preservation and protection from loss, injury or decay	KPC	Krill Protein Concentrate, a protein concentrate powder used as a food additive
continental shelf	The part of the ocean floor which extends from the shore to a depth of about 200 metres	krill	A small, shrimp-like crustacean found in huge swarms in Antarctic waters
convention	Agreement or practice established by general consent or accepted usage	larval	Very young stage of sea creatures
DDT	Dichloro-Diphenyl-Trichloroethane. A powerful insecticide	limu	Hawaiian term for seaweed
ecosystem	A group of plants and animals which are interdependent and within which energy is recycled by animals and plants feeding on each other	longline	A deep sea fishing line of great length with hooks on branch lines along it. Used extensively in tuna fishing
		management	The planning, direction and control of an enterprise

mangroves	Tidal forests, trees growing intertidally on the banks of rivers or sea coasts, particularly in estuarine areas	treaty	A formally negotiated settlement between nations.
mariculture	Cultivation of salt-water organisms	trolling	Fishing method: towing a single hook on a short line.
nautical mile	Term for the distance on the surface of the ocean. Equivalent to 1.152 land miles, 1.853 kilometres	trophic level	A step in the food chain, measured in terms of how many different organisms the organic material has been in since its original synthesis in plants.
nodules	Clumps of minerals found on the ocean floor.	utilisation	The process of making useful, of turning to some profitable account.
optimum	The best possible result which can be obtained given certain conditions.		
pesticide	Any substance, such as chemical poison, used to destroy plants or animals.		
polyculture	Raising several species together.		
protozoans	One-celled animals.		
purse-seine	A fishing net.		
quota	In fisheries management, the maximum amount of catch allowed from a stock.		
regulation	Rules and restrictions designed to keep good order and control.		
res communis	Latin term meaning common property.		
res nullius	Latin term meaning no man's property.		
spawning	The release of eggs into the water by sea creatures.		
surimi	A type of Japanese fish paste.		
Territorial Sea	Sea-coastal waters recognised in International Law as belonging to a nation; generally three miles from shore.		
thermal pollution	Overheating of water in bays, seas and rivers by discharge of hot water from manufacturing plants.		